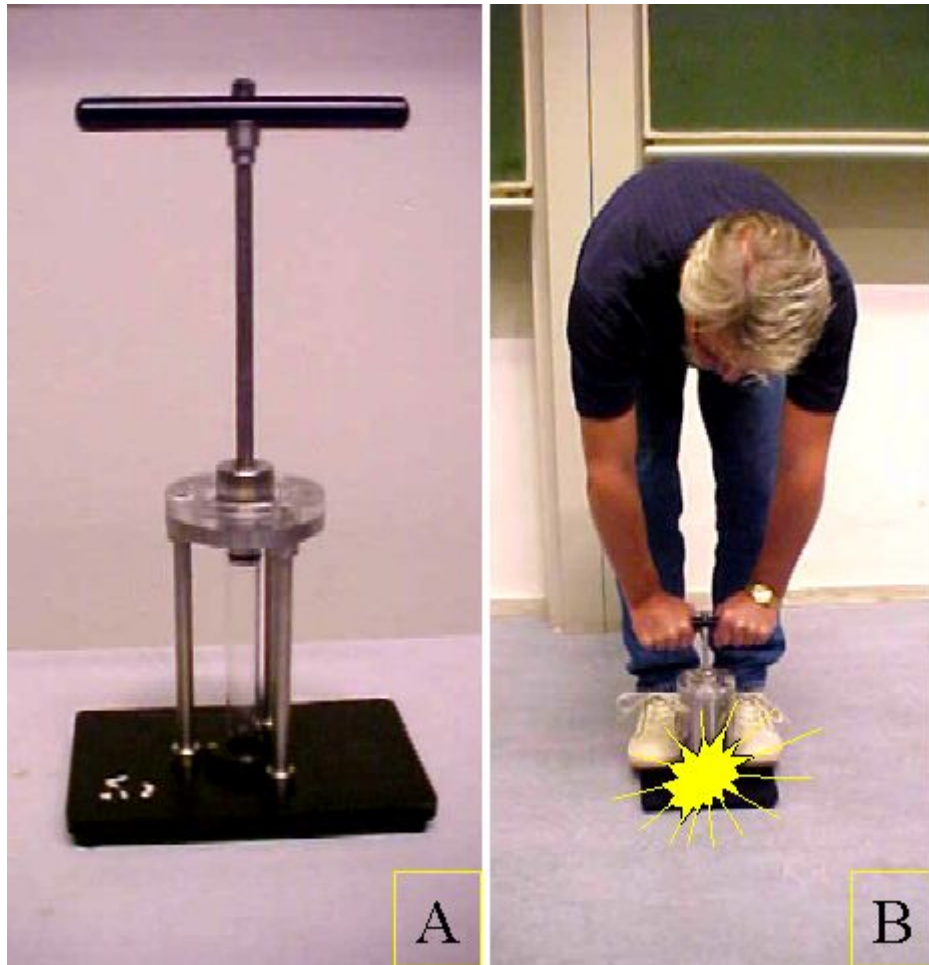


Fire-pump

Aim: To show that fast compression is accompanied by a considerable raise in temperature.

Subjects: 4B70 (Adiabatic Processes)

Diagram:



Equipment:

- Closed tube, fitted with plunger.
- Pyroxyll wire.

Fire-pump

Presentation: Small pieces of pyroxyll are put in the tube. The plunger is fitted into the tube and then pushed down rapidly. The pyroxyll lights and burns with a flash (see DiagramB). This points out to a steep increase in temperature.

Explanation: In general the process of the gas is polytropic, so: $pV^n = \text{constant}$. In this demonstration the air in the closed tube is compressed rapidly, so during this action there is almost no heat exchanged with the surroundings. Such a process is performed adiabatically, and $n = \gamma$, giving $pV^\gamma = \text{constant}$. Rewriting this in terms of

temperature gives: $TV^{\gamma-1} = \text{constant}$ and so: $T_2 = \left(\frac{V_1}{V_2}\right)^{\gamma-1} T_1$.

When the compression ratio $\left(\frac{V_1}{V_2}\right)$ is around 6 and using air ($\gamma=1.4$) we have: $T_2=6^{0.4}$.

$T_2=2T_1$. So starting at room temperature ($T_1=300\text{K}$), the air should heat up to around 600K (327°C)!

Remarks:

- Hold the tube firmly, so that when you press the plunger downwards forcefully the tube doesn't topple and break. We prevent toppling by standing on the foot of the construction.
- When the flash occurs you can feel also the rise in pressure

$$\left(p_2 = \left(\frac{V_1}{V_2}\right)^\gamma p_1 = 6^{1.4} = 12\text{bar}\right).$$

- We use pyroxyll wire, but you can also use small pieces of paper and/or the scrapings of a match. But do not use too much; more material means a higher heat capacity and as a consequence a lower temperature-rise of that material.

Sources:

- [Mansfield, M and O'Sullivan, C., Understanding physics](#), pag. 279-281.
- [Meiners, H., Physics demonstration experiments, part 2](#), pag. 800.
- [Wolfson, R., Essential University Physics](#), pag. 297-299.